INDUCTANCE OF A CO-AXIAL CABLE

Consider a co-axial cable with inner conductor radius ‘a’ and outer conductor radius ‘b’. The current through the coaxial cable be I.

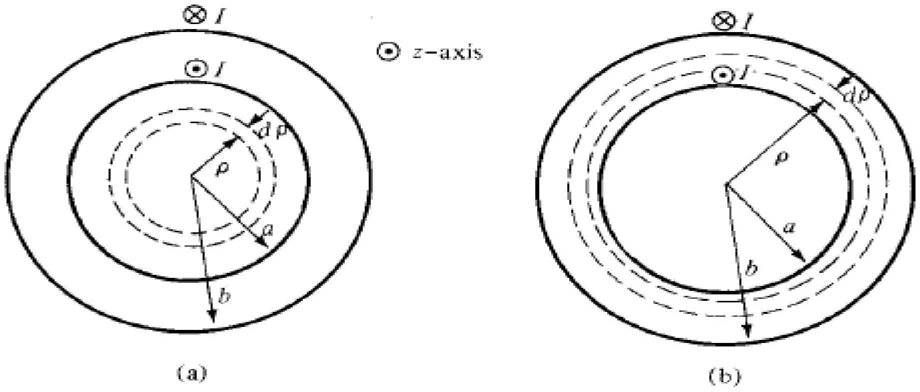

FIG: co-axial cable carrying current I

For the co- axial cable the field intensity at any point between the inner and outer conductors is given by,

H =$\frac{I}{2\pi\rho}$, where a<r<b

But B=$\mu H = \frac{\mu I}{2\pi\rho}$

The axis of the cable is along Z axis. The magnetic flux density will be in radial plane extending from $\rho = a$ to ρ=b.

And z=0 to z=d,

B=$\frac{\mu I}{2\pi\rho}$a$\emptyset T$

The total magnetic flux is given by,

$$\emptyset = \int_s B.ds$$

ds=d$\rho . dz. a\overline{\emptyset}$

$\emptyset = \int_{z=0}^{d} \int_{\rho=a}^{b} \frac{\mu I}{2\pi\rho}$ dρ dz. a$\emptyset$

= $\int_{\rho=a}^{b} \frac{\mu I}{\pi\rho} d\rho [z]_0^d$ a$\emptyset$

= $\int_{\rho=a}^{b} \frac{\mu I d}{2\pi\rho}$ dρ a$\emptyset$

$= \frac{\mu I d}{2\pi} [\ln(\rho)]_a^b$ a∅

$= \frac{\mu I d}{2\pi}$ [ln(b) –ln(a)]

$\emptyset = \frac{\mu I d}{2\pi} \ln\left[\frac{b}{a}\right]$

The inductance of a co-axial cable is ,

$L = \frac{total\ flux\ linkage}{total\ current}$

$L = \frac{\frac{\mu I d}{2\pi} ln\left[\frac{b}{a}\right]}{I}$

$L = \frac{\mu d}{2\pi} \ln\left[\frac{b}{a}\right]$ H

The inductance of a cable per unit length is ,

$\frac{L}{d} = \frac{\mu}{2\pi} \ln\left[\frac{b}{a}\right]$ H

MUTUAL INDUCTANCE:

The mutual inductance between the coils is defined as the ratio of flux linkage of one coil to the current in other coil.

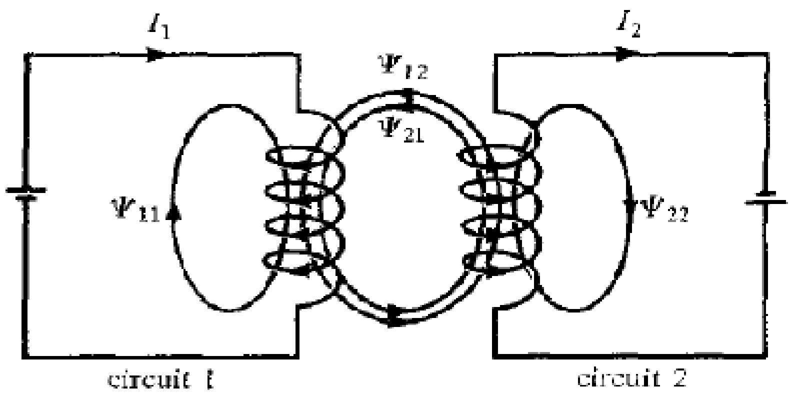

Fig: Magnetic interaction between two circuits

$M_{12} = \frac{N_2 \emptyset_{12}}{I_1}$ H

$\emptyset_{12 \rightarrow}$ $flux\ produced\ by\ I_1$ which links the second coil carrying the current I_2

Similarly ,

$M_{21} = \frac{N_1 \emptyset_{21}}{I_2}$ H

$\emptyset_{21 \rightarrow}$Flux produced by I_2 which links the first coil carrying current I_1

Magnetic Energy

The potential energy in electrostatic field is derived as

$$W_E = \frac{1}{2}\int D\,.E\;dv = \frac{1}{2}\int \varepsilon E^2\;dv$$

Derive the similar expression for energy in magnetostatic field. The magnetic energy in field of an inductor is

$$W_m = \frac{1}{2}\,LI^2$$

The energy stored in the magnetic field of an inductor is expressed in the form of B or H.

Consider a differential volume in a magnetic field is shown in fig. Let the volume be covered with a conducting sheet at the top and bottom conducting surface with current ΔI.